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ON THE USE OF CONDUCTING PLASTIC POTENTIOMETERS AS STRATA MOVEMENT SENSORS

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ABSTRACT

The nature and advantages of conducting plastic sensors are explored. Their use is described in terms of the instrumentation required, data gathering, processing, storage and transmission. The history of their use in the U.S.A., France and Canada is discussed. A summary of the Omnidata Polycorder is given which is to be used in conjunction with linear potentiometers.

UTILISATION DU POTENTIOMÈTRE À FIL CONDUCTEUR EN PLASTIQUE POUR DÉTECTER LE MOUVEMENT DES COUCHES SÉDIMENTAIRES

par

N.J. Stuart

RÉSUMÉ

Le résumé traite des caractéristiques du potentiomètre à fil conducteur en plastique et des avantages qu'il représente. On décrit le mode d'emploi de ce potentiomètre, le matériel requis ainsi que la collecte, le traitement, l'enregistrement et la transmission des données. On présente aussi les circonstances de son utilisation tant aux États-Unis qu'en France et au Canada ainsi qu'un exposé sur le microprocesseur *Omnidata Polycorder* qui est utilisé conjointement avec le potentiomètre linéaire.

CONTENTS

		Page
	ABSTRACT	i
1.	INTRODUCTION	1
	1.1 Conducting Plastic Potentiometers	1
	1.2 Format	1
	1.3 Signal Conditioning	1
	1.4 Rate Measuring	2
	1.5 Telemetry	2
	1.6 Data Processing and Storage	3
2.	CURRENT USE OF CONDUCTING PLASTIC POTENTIOMETERS	4
	2.1 USA	4
	2.2 France	4
3.	STRATA MONITORING IN CANMET	4
	3.1 Utilization of Results	5
4.	THE OMNIDATA POLYCORDER	6
	4.1 Calendar of Events	7
	4.2 Possible Expansion of Data Logging Project	7
5.	CONCLUDING REMARKS	8
6.	REFERENCES	8

1. INTRODUCTION

1.1 CONDUCTING PLASTIC POTENTIOMETERS

Traditional potentiometers are constructed from coils of resistance wire over which a contact is moved. The resolution is never much better than the diameter of the wire used. By replacing this wire by a substance such as conducting plastic, which presents a smooth contact against which the sweeper moves, the resolution becomes near infinite and the accuracy is improved. Thus it constitutes a device of instrumentation quality which for many applications rivals the conventional LVDT for accuracy, but is far simpler from the signal conditioning point of view.

1.2 FORMAT

The external design of the components does not differ significantly from the conventional potentiometer. Since they are more widely used as displacement transducers they are more often of the spring loaded, linear form. However rotary versions are available and are particularly suitable for incorporation in wire extensometers. Versions are also available in joystick formats and with logarithmic resistance scales.

1.3 SIGNAL CONDITIONING

Unlike the LVDT which requires an oscillator driven power supply and rectification of the signal, the linear potentiometer can work from a DC (or AC power supply). Further the output is in the form of voltages.

The position of the wiper determines the devision of the applied voltage. Some voltage determining devices work on a voltage comparison method. Thus, provided that the reference voltage is from the same supply (as that used for the transducer) the system should be little affected by battery condition. It should be noted that potentiometers are passive devices and that they cannot store energy in the way that the inductive LVDT's do. There are thus less considerations to make a potentiometer intrinsically safe than anLVDT.

The power supplies used typically have a potential difference of the order of 5 volts. Therefore no amplification would normally be required of the signal for most recording devices.

1.4 RATE MEASURING

Measuring the rate of change of signal may well prove to be an essential element. Closure measurements without this factor suffer from being unable to detect the absolute amount of closure, since there is invariable some prior to the installation of the instrument. In particular an increase in closure rate is taken by some to be a reliable warning of likely instability.

There are two basic approaches to measuring rates of change - analogue and digital. The most widely used analogue technique is referred to as sample and hold. Here a signal voltage is stored on a capacitor for a specified length of time and then compared with the changed signal voltage. Digital methods usually compare changes in digitised reading over a fixed period. An alternative method could be devised by running a clock to estimate the frequency of the least significant bit of the analogue to digital converter output.

1.5 TELEMETRY

a. Instrument Sensor Distance: Resistance in the connecting cable, with inductive effects, will give an effective maximum instrument-sensor distance. This can be enhanced by using a five core cable, by suitable screening and earthing. Beyond a certain distances - certainly over hundreds of yards - remote reading requires that the signals be transmitted in some manner other than as a voltage. The two most usual alternatives are as serial data and as a frequency.

b. Frequency Telemetry: A well tried and accurate technology already in use by CANMET in Sparwood for the telemetry of tilt station readings. Since with this method frequency is essentially an analogue commodity, systems tend to be restrictive in their control capacity.

c. Serial Data Telemetry: Here digital data is transmitted along a cable in a manner akin to the modems used for telephone communication between word processors. It enables data to be transferred in a number of different methods - allowing differing accuracies and checking protocols. Further it is ideally suited as a medium of communication between intelligent devices. It is also the method used by the CONSPEC system.

1.6 DATA PROCESSING AND STORAGE

The problem of data storage and processing begs the question of the use to which the monitoring is to be put. The two extreme uses are academic research and as warning devices. In the former case, there is no urgency for results, raw data may be processed at a remote laboratory months later - the requirement to store information may be large, however. In the latter case readings must be processed instantaneously and a warning given or not given. There is thus a requirement for processing but not for storage - at least beyond that for single and double differentiation with respect to time.

Between these two extremes, or encompassing these two extremes lies a justifiable project. One which initially gathers the data on which later prediction of danger may be based. There is an understandable reluctance by managers to install warning devices for which the basis for sounding a warning is not reliable. The desirable system is therefore modular. This implies that stations at which transducer signals are conditioned should be intelligent, have the capability of sounding warnings, have limited storage, and at the same time they should have the capability of networking to allow remote reading and storage of data.

Of the issues associated with processing the criteria for identifying instability is the most crucial. The input data is in the form of convergence readings from various stations. One may then compute rate of closure and change of rate thereof. Any warning criterion is likely to be a function of these three commodities: x, dx/dt and d^2x/dt^2.

The second issue concerned with processing is to identify the region and extent of the instability. It is important to know whether one is predicting a roof fall at an intersection or a generalised closure event involving the collapse of several pillars. This in turn might effect the warning criterion used and the degree of predictability.

2. CURRENT USE OF CONDUCTING PLASTIC POTENTIOMETERS

2.1 USA

Roger McVey of USBM Spokane (1) has developed a warning device using two convergence rod sensors. Convergence rate is measured by a "sample and hold" method sampling over a period of 10 seconds. The warning device may be set for various closure rates. The device is intended for use in depillaring. The rods are designed to be dragged out of an unstable area by their cables. As a true warning device it has no storage or interfacing capability. This instrument has been used at Smoky River Coal by McVey (the designer from USBM) and P. Wright (CMRC). It is not certified intrinsically safe.

The design of the instrument was given over to Serata Geomechanics. They have redesigned the electronics. The capabilities are substantially expanded and the rate determination is now digital.

2.2 FRANCE

Deniau, Leonet and Barou describe at 7th International Strata Control Conference (Belgium 1982) a microprocessor based device and its use and intended use in ironstone,coal and gold mines (2). This is more sophisticated than the USBM machine both in that the operational model was microprocessor based and in that the alarm is programmed to operate on change of rate of closure. Thus it is required to compute the second differential of closure. Additionally it is necessary to eliminate noise - the random component in measurement to which differentials are particularly sensitive. An increase in rate of closure is taken as evidence that failure is becoming likely - a decrease in closure rate taken as evidence of stabilization.

3. STRATA MONITORING IN CANMET

During the 1970's CANMET, M.Y. Fisekci in particular, developed a three channel mechanical pen recorder which could be used for recording the output of extensometers or load cells. Many such units were procured, some subsequently were damaged but several remain operational or even unused. It is intended that potentiometric instruments should replace these and expand their function.

Initially sensors can be read by use of an intrinsically safe multimeter - by measuring the resistances between all three wires thermal drift is eliminated. Reading, logging and telemetric devices were considered. Three lines of development were possible.

a. To use custom built apparatus, built by CANMET or under contract. This would be the cheapest most direct approach. It might have proven to be slow and involve difficulty with respect to networking intelligent stations and in writing systems software.

b. The sensors could have been tied into the Conspect system at Westar or elsewhere where it is applied. This is, no doubt, the quickest manner to get a remote monitoring system operating for rock mechanics. One would, however, be confined to sites with Conspec system and to the functions for that system.

c. The use of data logging devices which are currently available, programmable and able to communicate via a standard serial link. Such a strategy would be quick and easy to install (subject to certification). Such devices can initially perform a research function and later be programmed to operate as a warning/prediction device - assuming that this proves possible. This approach is relatively expensive - though not when compared with a complete Conspec system.

3.1 UTILIZATION OF RESULTS

Initially, the purpose of potentiometric devices is to replace, conveniently and cheaply, existing sensors. Thus, for example, the measurement of the closure of a roadway does not change in significance with the device with which it is measured. It is hoped however that significant strides may be made in accuracy, ease of installation, ease of reading (and therefore frequency of reading in time and space) and interpretation of results. There are three likely mechanisms by which benefits may be seen.

a. The increased accuracy together with the use of intelligent logging devices means that prediction models using the first and second differentials of closure with respect to time may be used to predict danger.

b. The ease with which a large number of sensors may be used means that the areal extent of an instability may be determined and excessive extrapolation avoided.

c. In particular where telemetric systems are used there is a much greater ability to respond to any increased closure. What is initially a research monitoring project can readily yield information to those concerned with operations or eventually be programmed to activate warnings for the benefit of the work force.

It is hoped that the advantages outlined above would have a feed back effect: that these advantages would result in increased enthusiasm by the engineering staff who, seeing the benefit, would put more effort into maintaining the system.

4. THE OMNIDATA POLYCORDER

Calgary CRL has procurred an Omnidata polycorder. This is a microprocessor controlled data logger with a 10 channel ADC, a 5 volt sensor power supply and an RS232 serial interface. Data is stored on 32K of RAM. Programming is in the proprietary language "Polycode".

This device may be used in a variety of modes from a point of view of geomechanics or mining research in general. These include:

1. As an electronic notebook - text and figures may be keyed in and stored - This has little advantage over an actual note book except that once entered the data may be moved directly to a computer.

2. As a portable device for reading sensors at different points of the mine and storing the data. Thus a large data gathering exercise could be hastened but there is still the requirement for each set of sensors to be visited for each reading.

3. As a logging device recording the sensor readings at preprogrammed intervals.

4. As a logging device which responds to specific events thus logging intervals are not predetermined. This is important for a work study type of application.

5. As an intelligent slave station in a network communicating via an RS232 compatible device.

6. As any of the above with the additional function of sounding warnings. The polycorder has the capacity to emit tones at a low volume; it is desirable that some additional warning device be used.

Two additional features of the polycorder are that it contains a real time clock/calendar and that it is almost entirely environmentally sealed. Thus it should be ideal for use in wet or dusty conditions.

The nature of the display and keypad make it desirable that much of the development of software be done through a computer - text requires 2-4 keystokes per letter on the keypad and the LCD is necessarily limited in size compared with a CRT. The only other area of concern lies in the polycorders nature as a desirable object - an object that might be pilfered. Superficially it resembles an electronic game although it is doubtful whether a pilferer could master polycode without a manual.

4.1. CALENDAR OF EVENTS

Delivery of the polycorder was taken in January 1984 followed by the plans required for certification as intrinsically safe. To date initial calibration work has been performed on the polycorder/conducting plastic potentiometer combination and at time of writing (February 14/84) the machine is with MRL Ottawa for certification.

It is hoped that the machine will be operational underground in some form by mid-summer. This requires reordering of potentiometers, development of sensors to accommodate the greater accuracy and software development.

4.2 POSSIBLE EXPANSION OF DATA LOGGING PROJECT

It is hoped to extend the work to include other types of sensor, especially strain gauge bridge types and to extend the type of work which can be performed by a polycorder. In particular in a clock driver autologging mode (see Section 4 (3)) uses have been contemplated which involve logging piezometers, logging the tyre temperature on dump trucks and monitoring the exhausts of underground diesel vehicles.

Of particular interest in the event driven logging mode (see Section 4 (4)) are time study applications which use the digital inputs, either switched directly by the events to be logged or else connected to an expanded manual entry keypad. Possible time study applications include roadway drivage and truck use studies.

5. CONCLUDING REMARKS

Conducting plastic potentiometers may be seen as a cheap and accurate component, the introduction of which is part of the introduction of electronic strata movement measurement.

The approach adopted here enables the flexibility to create systems aimed at gathering research data, performing as warning devices or acting as slave stations communicating with serial data. The major hardware investment (the Polycorder) is capable of a wider variety of logging functions which would currently facilitate CANMET.

6. REFERENCES

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